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Short Note

Use of bear's rub trees by mesocarnivores

Clara Tattoni[1,*], Francesco Rovero[2,3], Natalia Bragalanti[4], Claudio Groff[4], Marco Ciolli[5,6]

[1] *Dipartimento di Scienze e Tecnologie Agrarie, Alimentari Ambientali e Forestali, Università degli Studi di Firenze, Via San Bonaventura 13, Firenze, Italy*
[2] *Dipartimento di Biologia, Università degli Studi di Firenze, Via Madonna del Piano 6, Sesto Fiorentino, Italy*
[3] *Sezione di Biodiversità Tropicale, MUSE – Museo delle Scienze, Corso del Lavoro e della Scienza 3, Trento, Italy*
[4] *Servizio Foreste e Fauna, Provincia Autonoma di Trento, Via Trener 3, Trento, Italy*
[5] *Laboratorio di Ecologia Forestale, Università degli Studi di Trento, via Mesiano 77, Trento, Italy*
[6] *C3A – Centro Agricoltura Alimenti Ambiente, Via Mach 1, San Michele all'Adige (TN), Italy*

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Abstract

Rub trees are specific trees that bears mark with their scent to communicate their presence to possible partners or rivals. Adult males have been observed more frequently performing this behaviour especially during the mating season. Rub trees are recognizable from the other trees of the surrounding environment due to being larger or of a different species and because they are usually located along travel routes. Some authors suggested that bear rub trees are also likely to be marked by other species. Here we describe the usage of bear rub trees by mesocarnivores. Remote videos showed that carnivores of the study area marked bear rub trees with urine or scats in 4.5–8.5% of the visits and did so, on average, every 4 days. We run a GLMM to assess the probability of re-marking a tree against the age and type of the previous mark, the species that left it and the tree species, using tree ID and animal species as random factors. For all the species, the existence of a previous mark, regardless of its freshness and the species that left it, was the main driver for marking a tree, with great variability between trees. Results support the hypothesis that bear rub trees may function as a "chemical bulletin board" used by other carnivores. Because rub trees are important for animal communication, forest managers should be informed about their location and encouraged to avoid logging them.

Bear across the globe have been observed rubbing their back or other body parts on specific trees and several studies have demonstrated that this behaviour is a means of intra-specific communication (Tattoni et al., 2021; Filipczyková et al., 2017; Sato et al., 2014; Clapham et al., 2013a). Adult males have been observed to perform this behaviour more frequently than other age and sex classes, with rubbing frequency peaking during the mating season. These findings support the hypothesis that bears that use rub trees communicate their presence to possible partners or rivals. On the other hand, the usage of rub trees outside the breeding season is not completely understood. It has been linked to food availability (Clapham et al., 2013b) and navigation, as olfactory clues are used during movements (Bartoń and Selva, 2018).

Bears choose both live or dead trees for rubbing (Clapham et al., 2013a; Green and Mattsonl, 2003), but also rocks or power poles (Karamanlidis et al., 2007) and those objects are used by different individuals over time. The type of tree bears chose varies according to their environment. For example brown bears in Spain prefer birch, a relatively rare tree (González-Bernardo et al., 2021) while grizzlies preferentially mark firs and other conifers because the sap is supposed to preserve longer the chemicals contained in the scent mark (Clapham et al., 2013a; Green and Mattsonl, 2003). Rub trees have characteristics that make them conspicuous, such as a trunk of larger size or being of rarer tree species compared to the surrounding trees (Clapham et al., 2013a; Puchkovskiy, 2009). Rub trees are also often located along trails or forest roads (Green and Mattsonl, 2003; Tattoni et al., 2015). Bears like other carnivores choose to deposit their marks along path of high passage (Allen et al., 2017; Boitani and Powell, 2012) because it increases the likelihood of other individuals finding them.

Some authors have suggested, given the characteristics of bear rub trees, that they can also play an ecological role for other species that are more likely to use the same trees to leave a scent mark (Steenweget al., 2013; Mctavish and Gibeau, 2010). In Canada, Steenweget al. (2013) showed that 10 species of large mammals, particularly carnivores, were more likely to be detected by placing remote cameras on rub trees. Mctavish and Gibeau (2010) also suggested that rub trees are used as "chemical bulletin boards" by the mammalian community. In other words, rub trees are used as a common place where scent and mark are deposited and accessible by several individuals of different species.

In this work, we aim to describe the behaviour of carnivores captured by remote videos at bear rub trees in the Italian Alps. If rub trees are actually used as "bulletin boards", we expect that when previously marked by the same or another species, carnivores will respond to scent marking by re-marking the tree. We also expect animals to respond to fresher marks, as scent fades over time. Based on the literature, we also assume an effect of bear breeding season, and a preference for conifers over broad-leaved trees.

This study was carried out in an area of approximately 600 km^2 encompassing the Adamello-Brenta Natural Park in Italy (46°4′ N, 11°7′ E). The area is home to a diverse mammal community, including a re-introduced brown bear population of 50–60 individuals, a single male lynx (*Lynx lynx*) and some dispersing wolves (*Canis lupus*), at the

*Corresponding author
Email address: clara.tattoni@gmail.com, ORCID:0000-0003-1555-5669 (Clara Tattoni)

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Table 1 – Observed behaviours (%) displayed by carnivores during a 3 year survey of bear rub trees with remote cameras in the Alps, Italy.

Common name	Species	Investigate	Rub	No Action	Mark	N
Lynx	*Lynx lynx*	0.0	0.0	100.0	0.0	1
Wolf	*Canis lupus*	28.6	0.0	71.4	0.0	7
Fox	*Vulpes vulpes*	2.8	0.0	92.7	4.5	123
Martens	*Martes* sp.	5.4	0.0	87.1	7.5	280
Badger	*Meles meles*	6.5	0.0	85.1	8.5	355
Bear	*Ursus a. arctos*	35.0	20.7	43.4	0.9	546

time of the study (Groff et al., 2016). More than 150 bear rub trees have been identified in the park, mostly living trees and conifers, all located along forest roads or trails (Tattoni et al., 2015).

This study was based on the data described by Tattoni et al. (2015), collected by the Wildlife Service of the Province of Trento, the Science Museum of Trento and Adamello Brenta Nature Park. Data was collected during three years (2012–2014) at 25 bear rub trees with remote cameras, from March to November every year for about 9000 camera trapping days. The target species was brown bear but it also contained records of 30 by-catch species including 17 mammals, birds and people (see Tattoni et al., 2015 for the list of species). We retrieved all the records about the carnivores of the study area: lynx (*Lynx lynx*), wolf (*Canis lupus*), fox (*Vulpes vulpes*), pine marten *(Martes martes*), beech marten (*Martes foina*), badger (*Meles meles*) and Eurasian brown bear (*Ursus arctos arctos*). Beech marten and pine marten could not be distinguished from the images, and thus were referred to as *Martes* sp. We classified the observed behaviours according to the literature (Taylor et al., 2015; Clapham et al., 2013a), as reported in Tab. 1.

We built GLMM (Generalized Linear Mixed Models) with marking as the binary response variable, a binomial error distribution and a logit link function. We tested the following covariate as fixed factors: bear reproductive season (breeding/non breeding); the previous event (mark/no action); age of the most recent scent-mark in days, carnivore species and tree species. We used a binary classification to model the marking behaviour: 0) No action: when the animal was seen near the tree but did not mark it and 1) Mark: including rubbing, claw marking, urination or defecation on the tree or in its immediate vicinity. We included the tree ID as a random factor and in some models also the carnivore species, see Tab. 2. For each rub tree, the first observation of the year was omitted because there was no previous event. We ran GLMMs with different covariate combinations and we created an ANOVA table to select the best model, using `lme4` and `lmerTest` R packages (Bates et al., 2015; Kuznetsova et al., 2017).

The database yielded 2420 records of carnivores: a single record for lynx, 7 for wolf, 280 for martens, 546 for brown bear, 1230 for fox and 355 for badger. Even though the act of marking was relatively rare, most species rubbed, marked or investigated the trees (Tab. 1). Martens conspicuously investigated rub trees 15 times and marked them 21 times while badgers marked the trees 30 times and investigated 23 times. Foxes also investigated 35 times and marked the trees 55 times. Bears were filmed while rubbing 114 times and debarking

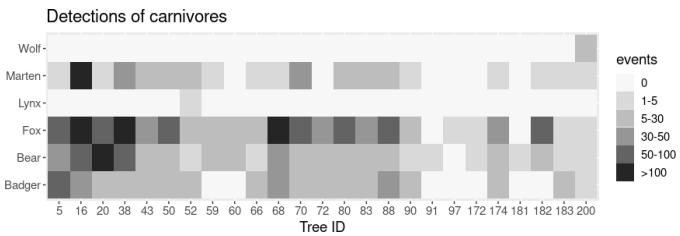

Figure 1 – Carnivore richness and number of detections at 25 bear rub trees in the Italian Alps during a three year survey. Each cell of the plot represents the total number of detection events per site of a given species cumulated for all samplings.

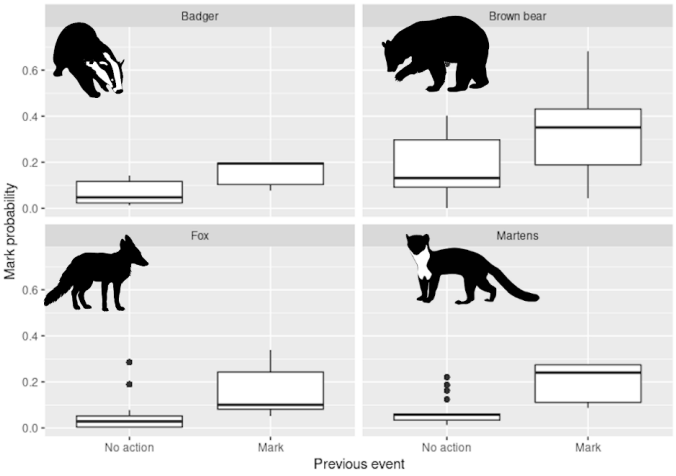

Figure 2 – Predicted probability of marking a bear rub tree by four carnivores in the Italian Alps, in response to the previous event, where 'Mark' means that a carnivore left a scent mark on the tree in the previous passage and "No action" means that it didn't.

the trees 5 times. The wolf stopped twice to sniff the air near the trees before continuing on its way, and the lynx was indifferent.

The carnivores were recorded across all the study area (Fig. 1), except the lynx and wolf that at the time of the study consisted only of only one or a few transient individuals. The number of detections recorded at each tree varied greatly (mean 96.76, range 1–440 SD 102.35). The 6 species never co-occurred at the same site: the average number of species found at rub trees was 4 (1–5 SD 1.5), and (5) The highest species richness (5) was detected at 2 rub trees (ID 5 and 200) and the lowest also in two sites (ID 91 and 97).

When considering the previous event (mark/no action), we also recorded the species that performed it. Same species over-marking occurred 60 times (fox 37, bear 15, badger 7 and martens 1. In the majority of cases (110 out of 170 re-markings), carnivores marked over the odour left by a different species.

Before running GLMM we discarded the data of the lynx and wolf and retained 1666 records. The best model had 'previous event' as significant fixed factor (p <0.05) and both ID and carnivorous species as the random effects (model 7, Tab. 2). Contrary to our expectations, the age of the scent mark was not significant in any of the models. In this study, the effect of time might not be significant because the trees were marked quite frequently, on average every 4.3 days (1–63, SD 6.8).

For all the species, the main driver for marking a tree was the presence of a previous mark. However, the probability of marking varied across species (Fig. 2) and sites with brown bears appearing to be to more influenced by the tree ID compared to martens, fox and badger (Fig. 3).

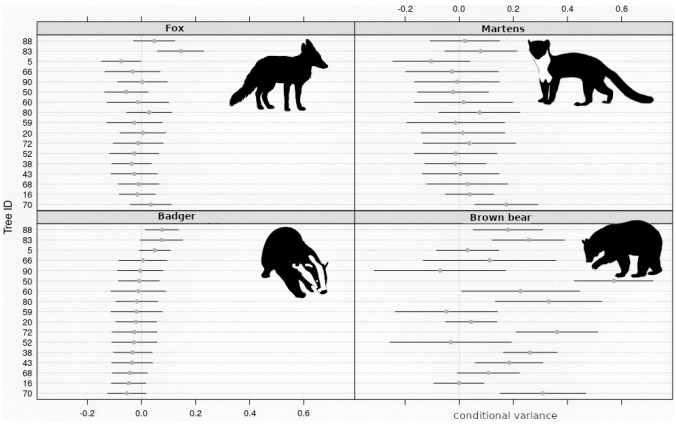

Figure 3 – Among-site variance of the probability of marking by four carnivores at bear rub trees in the Italian Alps as estimated by the best GLMM model using tree ID and species as random effects.

Table 2 – ANOVA table of competing models for rubbing behaviour of carnivores at bear rub trees in the Alps."Mark" is the binary response variable (mark, no action), "previous_mark" is a binary variable (mark, no action) recorded at previous passage of a carnivore, deltat is the time elapsed from the previous event, species is the marking species, ID is the rub tree id code and season is a binary variable bear breeding season (breeding,not breeding).

	Competing models	**AIC**	$\chi 2$	**df**	p
1	$mark \sim previous\_mark + (1\|ID)$	557.88	–	–	–
2	$mark \sim deltat + previous\_mark + (1\|ID)$	559.29	0.59	1	0.443
3	$mark \sim species + previous\_mark + (1\|ID)$	459.70	103.59	2	<0.001
4	$mark \sim deltat + species + previous\_mark + (1\|ID)$	461.67	0.04	1	0.848
5	$mark \sim season + deltat + species + previous\_mark + (1\|ID)$	456.99	6.68	1	0.010
6	$mark \sim season + deltat + tree\_sp + previous\_mark + species + (1\|ID)$	458.34	0.64	1	0.422
7	$mark \sim previous\_mark + (1 + species\|ID)$	414.13	50.21	3	<0.001
8	$mark \sim previous\_mark + deltat + (1 + species\|ID)$	416.11	0.02	1	0.88

This difference between bears and the other carnivores could be due to species-specific marking strategies. According to Morehouse and Boyce (2016), bears may have a preference for where to rub, and adult dominant males rub more frequently than subadults (Tattoni et al., 2021; Clapham et al., 2013a). As a result, we can expect rub trees within dominant males' home ranges to be used more frequently than other rub trees. To understand the bear preference for a specific tree, it will be necessary to identify individual bears as well as design a different experiment, possibly involving some tree manipulation. Bears have a complex communication system, based not only on scent, but also on visual marking and tree debarking (Penteriani et al., 2021).

In the Alps, as in Canada (Steenweget al., 2013), rub trees were located in places of transit for many species, confirming their usefulness for biodiversity monitoring. We were able to record 6 species of forest carnivores including wolf and lynx, which is very rare in the study area. All species marked and/or investigated the same trees as bears. Our results support the hypothesis that bear rub trees can have a function in creating the smellscape for the carnivore community. This hypothesis could be better tested by comparing the trap-rates and marking behaviour on random chosen trees (not only rub trees). Because rub trees are important for animal communication, forest managers should be informed about their location and encouraged to not log them.

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